

Advances in Feedlot Management:  
Factors Affecting Efficiency of Gain, Marbling and Adipocyte Development

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Feedlot nutrition and nutrition continually evolves. With this evolution comes new information on growth and development, vitamin impacts on fat cell development, and the development and use of new feed ingredients.

First, you need to understand that all nutrients (energy, protein, vitamins, minerals, and water) are used in a hierarchy that goes from maintenance > development > growth > lactation > reproduction > fattening. This means that an animal must have sufficient nutrients to maintain its body before bone or muscle growth can occur, and these must occur before fattening can occur. The second thing that you need to understand about ruminant nutrition is that feed is digested in the rumen by ruminal bacteria that attach to the surface of a feed particle to digest it. In ruminants, maintaining the digestive organs (rumen, reticulum, omasum, abomasum, small intestine, and large intestine) plus the liver and kidneys can take as much as 40-50% of the energy and 30-40% of the protein consumed in a day. Forage diets that are very bulky and only 40-60% digestible increase the weight of the digestive tract, because more undigested feed remains in each segment of the digestive tract. In contrast, grain-based diets result in decreased organ weights compared with forages, because grains are 80-100% digestible, and have a much smaller particle size, which allows them to have a faster rate of digestion and passage through the digestive tract. The result is that grain is more digestible than forage, plus it decreases an animal's maintenance requirement by resulting in less digestive organ mass, leaving more nutrients for muscle growth and fattening.

Feedlots take advantage of the energy content and digestive characteristics of grains to finish cattle. However, if you have a grass-based system for your cows (like most of the world), you aren't going to switch to grain. One way to increase an animal's performance with forages is grinding the forage to increase its' digestibility by making more surface area available to ruminal bacteria and increasing the rate of passage of the forage through the digestive tract, decrease the bulk fill inherent with the forage, and decrease the animal's maintenance requirement by decreasing the digestive tract weight. However, increasing the surface area of a forage diet is not the only answer, because not all gain is the same, and what you feed an animal affects the carcass characteristics.

Typically, cattle are finished on high concentrate diets for a period of time ranging from 80-280 days prior to slaughter. This finishing period allows for more rapid, efficient growth, and increased intramuscular fat (marbling) deposition so that the cattle carcasses grade choice compared with cattle grown on forage-based feeding systems. In general, tissues are deposited in the order of: brain > bone > muscle > fat. Nevertheless, A young, rapidly growing animal that is in a linear phase of growth will naturally put on more bone and muscle, and has a higher protein requirement from the standpoint of dietary concentration of protein than an older animal. Sainz et al. (1995) reported steers fed a high-forage growing diet had 21% ( $P < 0.01$ ) greater maintenance requirements during the finishing phase compared to those grown on a high-concentrate diet and slaughtered at the same carcass weight. In a feedlot study where cattle were fed an 85% concentrate diet with 15% corn silage using either a restricted in intake to achieve a desired gain

that went from 1.13kg/d for 70 days to 1.36 kg/d for 63 days to ad libitum intake for the final 27 days, for a total of 160 days in the feedlot compared with cattle fed ad libitum (all they could consume) for 159 days in the feedlot, the cattle that had their gain programmed used 140 kg less total feed, and there was no significant difference in the final weight of 549 versus 542 kg live weight. However, the programmed gain cattle had less back fat with no difference in marbling (intramuscular fat)(Knoblich et al., 1997).

The major volatile fatty acids (VFA) produced by rumen microorganisms are acetate, propionate, and butyrate. These VFA are the main products of the digestion of feed by bacteria in the rumen, and serve as the main precursors for both glucose and fat in ruminants. On a forage based diet, the proportion of VFA would be approximately 65-70% acetate, 15-25% propionate, and 5-10% butyrate. Feeding diets high in readily fermentable carbohydrate (starch) increases the proportion of propionate produced through ruminal fermentation, and results in VFA proportions of approximately 50-60% acetate, 35-45% propionate, and 5-10% butyrate (Johnson et al., 1982). When animals are fed a high concentrate diet, the amount of propionate produced increases relative to acetate. The importance of this is that propionate is the major glycogenic fatty acid (fatty acid converted to glucose in the liver), which increases average daily gain and marbling. Smith and Crouse (1984) conducted a study where they fed either a corn silage (low energy) or ground corn (high energy) diet to Angus steers from weaning, at 8 months of age, to a terminal age of 16 or 18 months of age. They reported that acetate provided 70 to 80% of the acetyl units for lipogenesis in back fat, but only 10 to 25% of the acetyl units for lipogenesis in intramuscular fat. Conversely, glucose (from propionate) provided 1 to 10% of the acetyl units for lipogenesis in back fat, but 50 to 75% of the acetyl units for lipogenesis in intramuscular fat. The authors concluded that different regulatory processes control fatty acid synthesis in intramuscular and subcutaneous fat.

Vitamin A is an essential vitamin for normal growth, reproduction, epithelial tissue, and bone development. Cattle consume pro-vitamin A compounds such as alpha-carotene, beta-carotene, gamma-carotene, cryptoanthin, and carotenoids from both forages and grains, and grazing cattle are considered to have ample vitamin A stores due to the high intake of carotene from forages, with liver and adipose tissue being the main storage sites of vitamin A in cattle. Cattle convert 1 mg of beta-carotene to approximately 400 IU of vitamin A (120 µg retinol) via 15,15 dioxygenase in the intestinal epithelium and liver (NRC, 2001).

Oka et al., (1998) reported that serum vitamin A concentrations were negatively correlated with marbling scores, and subsequent feeding studies reported that low vitamin A diets fed between 10 and 30 mo of age resulted in decreased serum and hepatic liver stores, and increased marbling (Oka et al., 2004, Nade et al., 2003). The stores of vitamin A must be depleted in order to remove the inhibition of vitamin A on adipocyte differentiation to increase marbling in beef cattle.

The NRC (1996) recommends that growing beef cattle receive 2,200 IU vitamin A/kg dry feed. Research conducted with Angus-cross steers fed for 145 days (Gorocica-Buenfil et al., 2007a), Holstein steers fed for 243 days (Gorocica-Buenfil et al., 2007b), and Angus-cross steers fed for 168 days (Gorocica-Buenfil et al., 2007c) has found that feeding diets with approximately 1,000 to <1300 IU vitamin A/ kg DM supplied as β-carotene in corn-based diets, without supplemental vitamin A, increased intramuscular (i.m.) fat deposition, commonly referred to as marbling, and USDA Quality Grades without affecting subcutaneous (s.c.) or visceral fat, average daily gain, feed efficiency, or calf health, compared with cattle receiving 2,200 IU supplemental vitamin A daily (Gorocica-Buenfil et al., 2007a,b) or 2700 IU supplemental vitamin A daily (Gorocica-Buenfil et al., 2007c). Gorocica-Buenfil (2007c) reported that it took 56 days to reduce

serum retinol, but at harvest, serum retinol was 44% lower in steers not supplemented with vitamin A compared with those supplemented with 2700 IU supplemental vitamin A daily. The length of Vitamin A restriction is important, because sufficient time is necessary for liver and adipose storage depletion, preadipocyte proliferation and differentiation, and adipocyte triacylglycerol filling to improve marbling.

The choice of supplemental protein for corn silage based growing diets was investigated by Felix et al. (2014). In diets containing 79% corn silage on a dry matter basis, urea, soybean meal, and dried distillers grains were compared as the sole source of protein in diets formulated to contain 10.8% crude protein. The urea treatment resulted in lower dry matter intake, average daily gain, and final weight in this 84 day study. This contrasts with the results of slow release urea reported by Holland and Jennings (2011) using an 82% dry rolled corn diet with 8% alfalfa hay when soybean meal was compared with slow release urea, or a slow release urea and soybean meal mix in a 12% crude protein diet. In this study by Holland and Jennings (2011) there were no differences in performance or carcass characteristics due to protein source. The study by Felix et al. (2014) was a lower energy and lower protein diet, but also a much wetter diet. When feed bunks are outside during wet conditions, or when a wet diet is fed, the use of urea may not be appropriate; as the length of time the diet is exposed to wet conditions may impact the ability of non-protected urea to remain in the feed bunk, as Cole et al. (2006) reported that 30% to 50% of feed nitrogen may be lost to volatilization, primarily as ammonia.

Production systems and feedlot nutritional programs vary widely in the beef industry. Developing feeding strategies to produce economically viable and consumer acceptable beef is critical to the advancement of the added-value beef industry. In all feedlot systems, the most critical management area is animal health. Management for optimal health starts with nutritional programs that boost the immunity of the calf, from the neonatal period through high-quality colostrum. This can have impacts on animal health, growth rate, feed efficiency, and marbling as an animal's passive immune transfer, at birth, may be an important factor in an animal's susceptibility of bovine respiratory disease (Galyean et al., 1999). Since respiratory disease impacts growth, meat characteristics, and marbling, management and nutrition practices that keep cattle from becoming sick is very important, because diagnosis of cattle with respiratory diseases is very difficult, and diagnosis at the feedlot level does not have a close correlation with lung lesions associated with respiratory illness. Research at the USDA Meat Animal Research Center (Wittum et al., 1996) found that 35% of 469 steers in one study were treated for a respiratory disease episode between birth and harvest. In their study, 78% of treated cattle had lung lesions at harvest, and 68% of untreated cattle had lung lesions at harvest. While both groups had high percentages of lung lesions, the authors concluded that if an animal was sick enough to be identified as having a respiratory illness and treated, performance reducing lung damage had already occurred. If a calf gets a respiratory disease, tissue damage occurs, and nutrients are diverted from lean growth and marbling toward repair of the damaged tissue. Therefore, to insure that an animal's health and management history did not limit its ability to deposit marbling or to grow to its potential, individual animal identification, management, and marketing should be practiced.

In conclusion, feedlot nutrition and management are constantly evolving. What was appropriate to recommend just a few years ago is outdated, now. The important thing to remember is that there are ways to improve efficiency, alter the composition of gain, improve animal welfare, and increase profit potential with the incorporation of new feeding and management strategies.

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